EFFECT OF STRONG N-TH COUPLING ON CORE DESIGN CALCULATIONS BASED ON A TYPICAL 100 MWE INTEGRAL PWR DESIGN

IAEA-CN-327-020

Nuclear science and thechnology research institute

Y. Abbassi[1*], R. Akbari[1], J. Mokhtari[1]

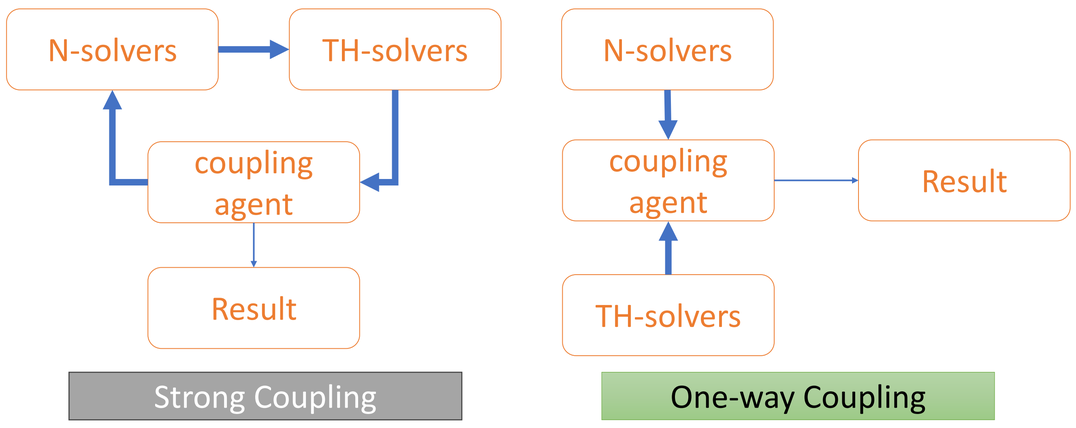
[1]Nuclear Science and Technology Research Institute

[*]Corresponding Author Email: yabbasi@aeoi.org.ir

International Conference on Small Modular Reactors and their Applications

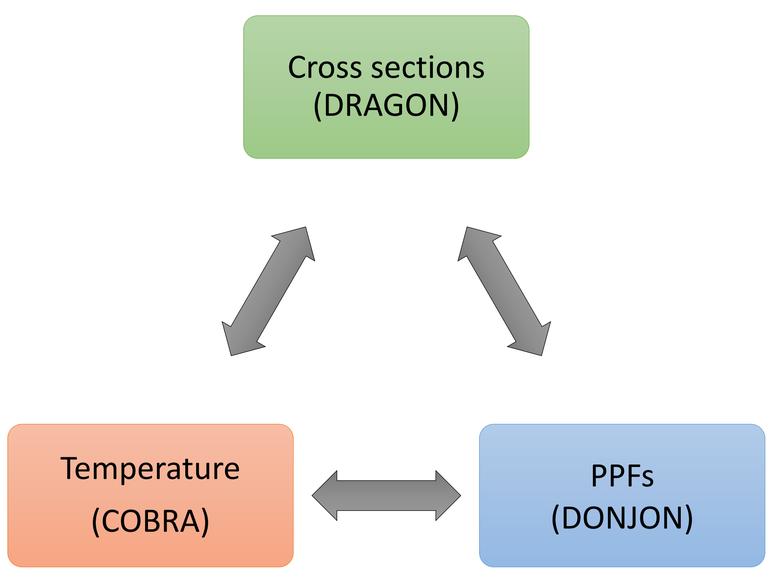
INTRODUCTION

- Reactor core **design** relies on simulation techniques
- Neutronics and thermal-hydraulics software tools are used
- Most of these software tools (codes) are **interdependent**
- N-calculations rely on the nuclear cross section data
- TH-calculations for safety parameters such as CHF, MDNBR
- One-way coupling: N and TH solvers are utilized independently.
- Strong coupling: N and TH solvers are interconnected.
- Aim: Comparison between one-way vs strong coupling
- Aim: the core of a typical 100 MWe SMR



METHODS AND MATERIALS

- Neutronic cell calculations (DRAGON): cross sections
- Neutronic core calculations (DONJON): PPFs
- Thermal-hydraulic calculations (COBRA): Temperature



- The convergence is checked
- Above stages are iterated to reach convergence criteria

RESULTS

code by code verification

Neutronics:
deterministic
Vs
probabilistic

TH:
flow channel
Vs
PARCS TH Module

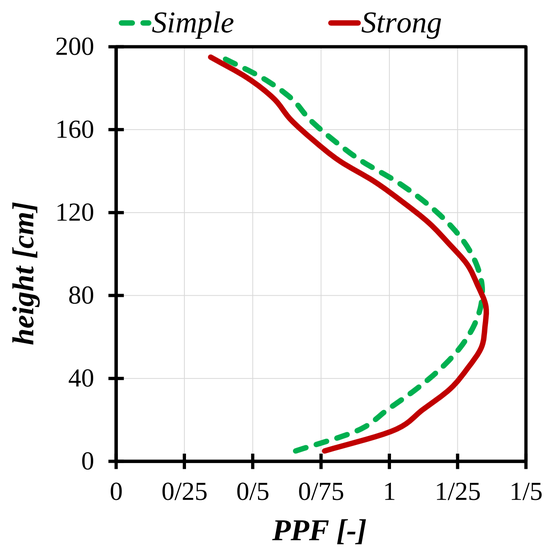
Validation	Neutronic	Thermal-hydraulic
Current study	DRAGON DONJON	COBRA
Validation codes	OpenMC	PARCS
Error	Max: 2.4% Ave:1.5%	324°C Vs 323°C

K_{eff} at the BOC
- Simple coupling→ 1.000593
- SAR→ 1.005724
- Difference: ***513 pcm***

Radial PPF Values
- Simple coupling→ 1.1303
- Strong coupling → 1.1165
- Difference: ***1.23%***

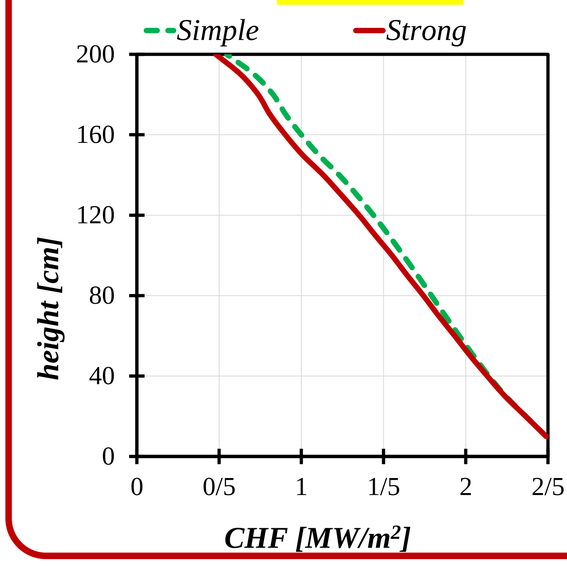
Axial PPF Values
- Simple coupling→ 1.3390
- Strong coupling → 1.3530
- Difference: ***1.03%***

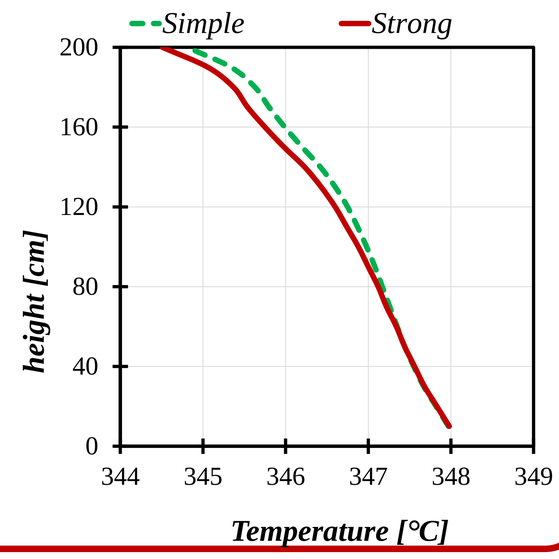
Average CHF Values
- Simple coupling→ 1.338789 kW/m^2
- Strong coupling → 1.253989 kW/m^2
- Difference: ***84.8 kW/m^2***



highest CHF temperature difference is around 0.25 K

15.9% relative error in the MDNBR calculations





CONCLUSION

- ✓The core calculations of a typical **100 MWe** integral SMR
- ✓(1) An **one-way** thermal-hydraulic and neutronic calculation
- ✓(2) Same calculation with **strong iterative coupling** method
- ✓Neutronic verification: against probabilistic approaches.
- ✓Thermal-Hydraulic verification: against PARCS code.
- ✓Both approaches (1) and (2) yielded acceptable average results
- ✓Data obtained with a simple method are not very trustworthy
- ✓There is a 15.9% relative error in the **MDNBR** value

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